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NREL PV System Performance & Standards Technical Progress

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NREL PV System Performance & Standards Technical Progress

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ABSTRACT

This paper presents a brief overview of the status and accomplishments during Fiscal Year (FY)2004 of the Photovoltaic (PV) System Performance & Standards Subtask, which is part of PV Systems Engineering Project (a joint NREL-Sandia project).

1. Objectives

The near-term objectives of this subtask are to strongly support the subcontracts involving thin-film module deployments in hot and humid climates, including active participation on the Thin Film Module Reliability Team. The other primary objective is to lead, support, and document advances in national and international standards and codes. The long-term objectives are to continue detailed, long-term performance monitoring of grid-tied and stand-alone PV systems in order to observe and document changes in prototype and thin-film modules.

2. Technical Approach

Long-term testing of prototype modules in small systems, both grid-tied and stand-alone, provide information about reliability and performance on statistically significant numbers of modules. PV standards development are supported through several subcontracts, as well as in-house participation on PV standards committees. Cooperation and joint projects with PV manufacturers, systems integrators, and utilities are used to aid identification of potential problems prior to widespread commercial deployment.

3. Results and Accomplishments

3.1 PV standards

PV standards development was supported through a number of subcontracts, including the U.S. PV certification program, PowerMark Corp., and the Secretariat position of the International Electrotechnical Commission (IEC) Technical Committee for photovoltaics (TC-82). These subcontracts are reported elsewhere at this review meeting [1,2]. A subcontract was awarded late in FY2004 to Endecon Engineering to develop a new standard for rating the performance of PV systems to Performance Test Conditions (PTC), which are described below. Lastly, support for ASTM PV standards activities continued through chairing subcommittee E44.09 on Photovoltaic Electric Power Conversion.

3.2 Outdoor Test Facility (OTF) systems

Long-term testing of the NREL systems monitored at the OTF continued during FY2004. These systems include crystalline-Si (3), a-Si (4), CdTe (2), and Cu-In-Ga-S-Se (1).

The primary method used to analyze the performance of these systems was with monthly PTC regression fits to the measured DC output power, as described in Ref. [3]. Performance reports are generated quarterly and delivered to the module manufacturers. An example of a PTC regression as a function of time is shown in Fig. 1. This a-Si system is the oldest system at NREL and has been monitored for over ten years with a degradation rate of just 1% per year. The PTC ratings are also being applied to subcontractor data from the thin film module hot and humid exposure program.

During the past year, a few major system failures or problems were observed. The single-axis Delta tracker, which uses Applied Photovoltaic Systems (APS) single-junction a-Si modules, failed when the actuator arm broke away from the tripod support frame (see Fig. 2). Because of this event, and because almost half the modules are currently cracked, this system will be scrapped.

In August 2004, the inverter for the Solar Cells Inc. CdTe system went offline with an internal fault. The problem was corrected by replacing the main printed circuit board inside the inverter. This same inverter had to be reset twice prior to this failure when it tripped off.

Several modules in one of the thin-film systems developed hot spots 30°C above the normal module temperature, as seen in Fig. 3. The hot spots have not yet resulted in a measurable power loss or a complete system failure, and are currently being closely watched for future changes. Note that the manufacturer has asked that we not identify this system.

Because all the rack space in the OTF array field is currently occupied, adding additional systems for long-term monitoring is not possible. To alleviate this situation, space that had been occupied by two large and obsolete two-axis trackers has been reconfigured. Four new array structures have been constructed during FY2004 that are large enough to hold one or two new systems each (Fig. 4). It is anticipated that these will be gradually used for new grid-tied systems using state-of-the-art modules, both crystalline and thin-film.

3.3 Collaborations

During FY2004, a number of collaborations with organizations outside of NREL have been initiated. Mutual site visits with Arizona Public Service and PowerLight Corp. were conducted to determine possible avenues of cooperation involving PV system data analysis. These efforts will continue in the future. Representatives of First Solar, Inc. visited the OTF in May 2004 for a comprehensive review of the performance of the CdTe system operating since 1995.

As a result of a Memorandum of Understanding between the U.S. and Indian governments, an evaluation of thin-film modules at India's Solar Energy Centre (SEC) near New

Delhi. This work is documented in a separate paper at this review meeting [4].

3.4 Stand-alone systems

An important achievement in FY2004 was the final approval after several years of development of IEEE Standard 1526 on stand-alone PV system performance, which proscribes tests on the entire system, including batteries and load.

3.5 PVWATTS

This software package provides energy production and cost savings information for grid-connected PV systems located anywhere in the United States. A number of enhancements have been added, including specification of the system location through postal zip codes or by latitude and longitude coordinates [5].

4. Conclusions

Progress has been made in the study of PV system performance, and efforts are underway to expand this work in the future. All milestones for this subtask listed in the FY2004 Annual Operating Plan have been met.

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The contributions of the NREL staff members working on this subtask are acknowledged: Peter McNutt, Bill Marion, Bill Sekulic, Jill Adelstein, Tom McMahon, and Bob Hansen. In addition, members of the PV Measurements and Characterization Group generated many module performance test reports that are an integral part of this work: Steve Rummel, Allan Anderberg, and Larry Ottoson. This work was supported by the U.S. Department of Energy under contract no. DE-AC36-99GO10337.

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MAJOR FY 2004 PUBLICATIONS

IEEE Standard 1526, "Recommended Practice for Testing the Performance of Stand-Alone PV Systems," The Institute of Electrical and Electronics Engineers, Inc., New York, NY 10016-5997, ISBN 0-7381-3828-2 SH95177.

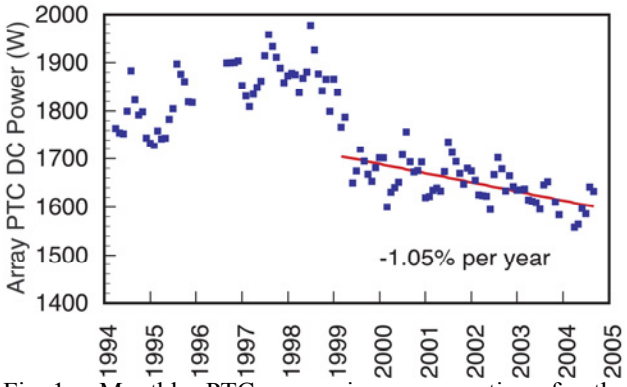

Fig. 1. Monthly PTC regressions versus time for the OTF United Solar Systems Corp. a-Si grid-tied system.

Fig. 2. Rear view of the Delta tracker in the OTF array field showing the failed actuator and several cracked a-Si modules.

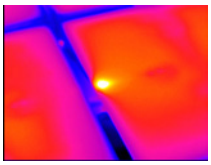

Fig. 3. An infrared camera image of a hot spot at the edge of a module that is part of one of the OTF grid-tied thin film systems.

Fig. 4. Two of the new system support racks recently installed in the OTF array field.

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